FIG. 1A

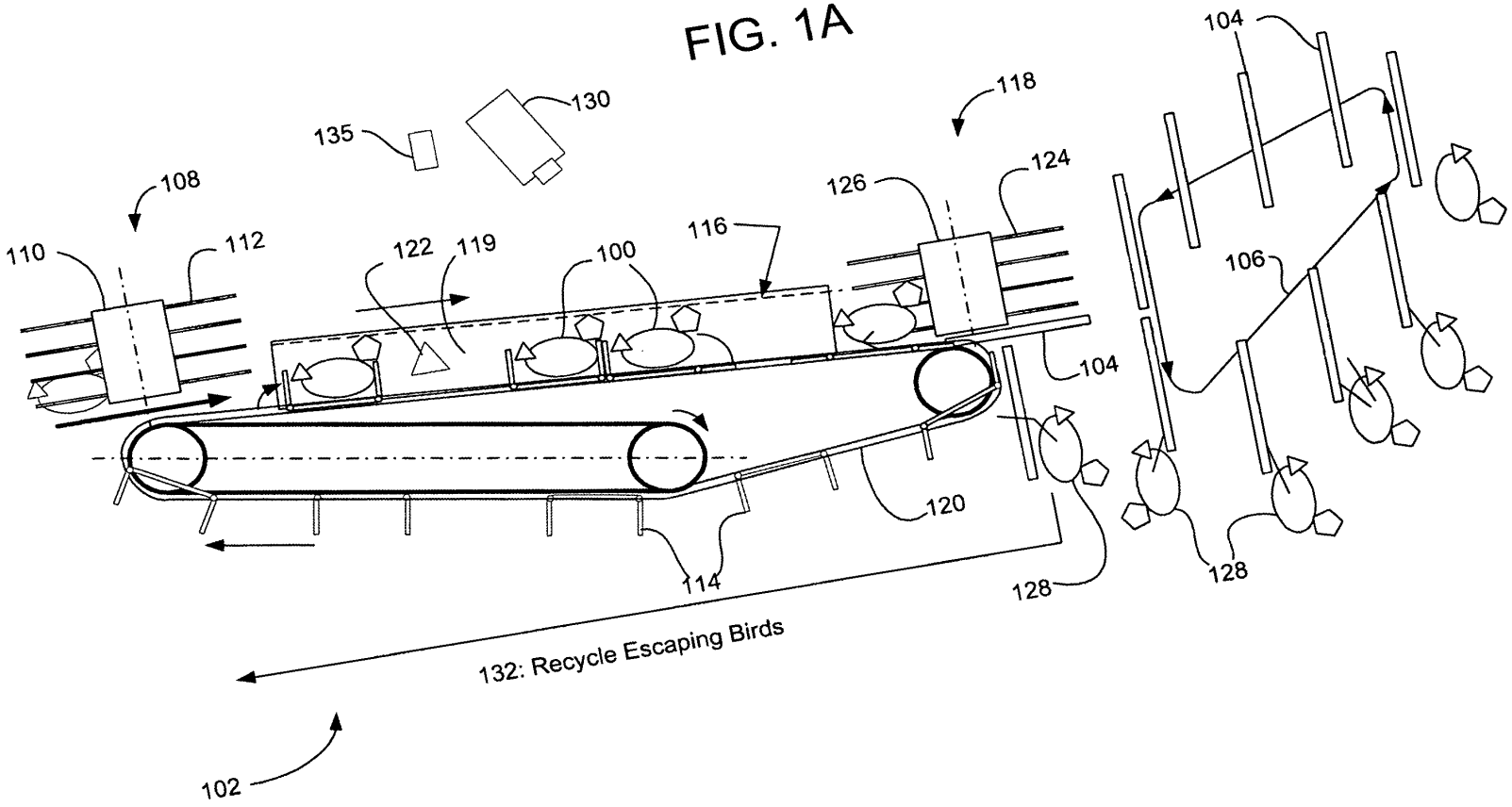

135
130
118
108
124
126
110
112
122
119
100
116
104
106
120
114
128
128
132: Recycle Escaping Birds
102

FIG. 1B

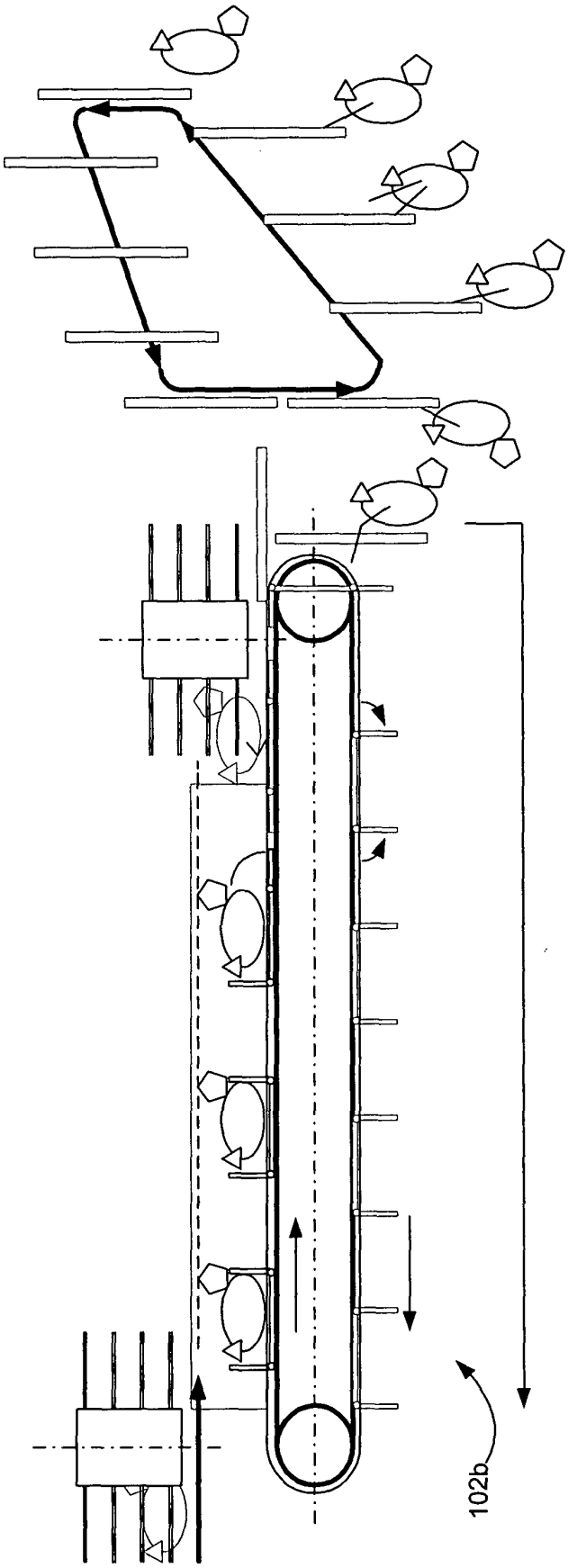


FIG. 1C

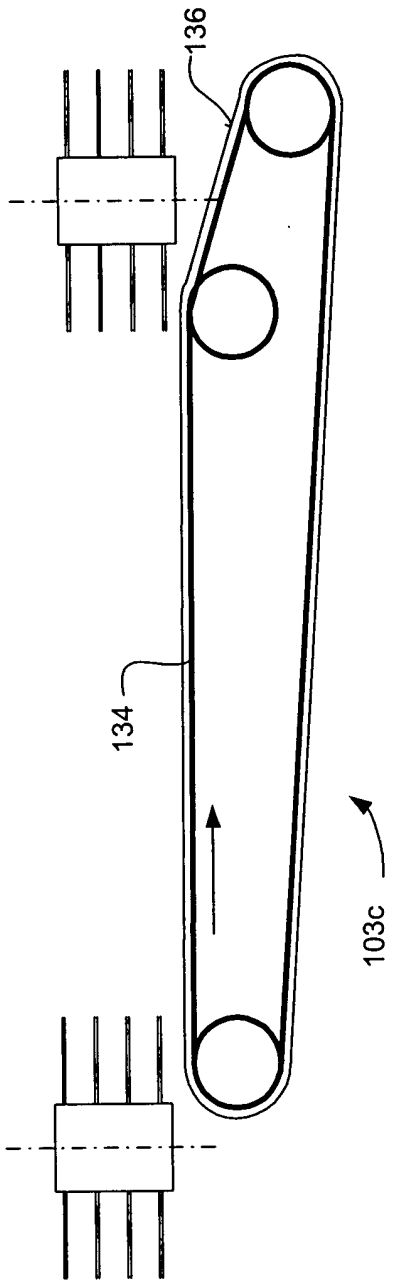


FIG. 2

Singulating System

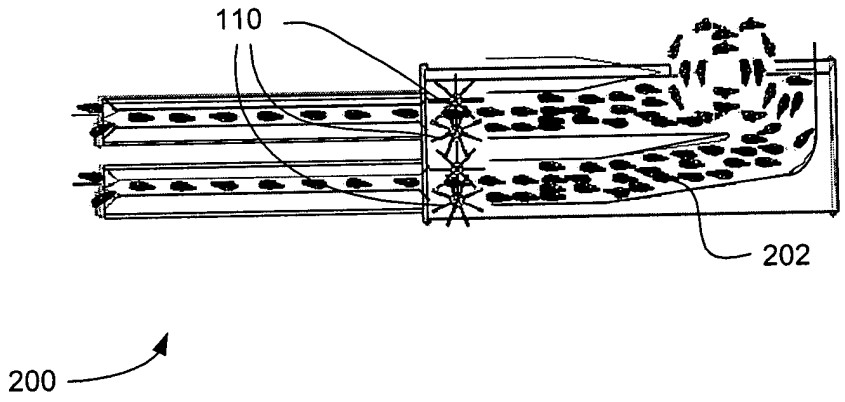


FIG. 3

Pallet

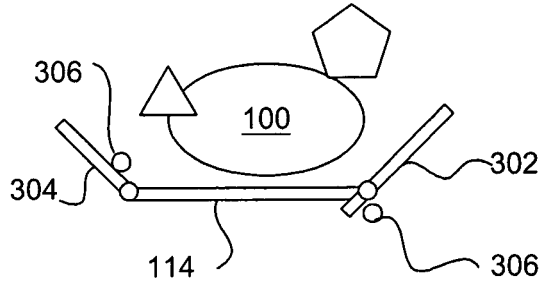


FIG. 4

Leg Gripping

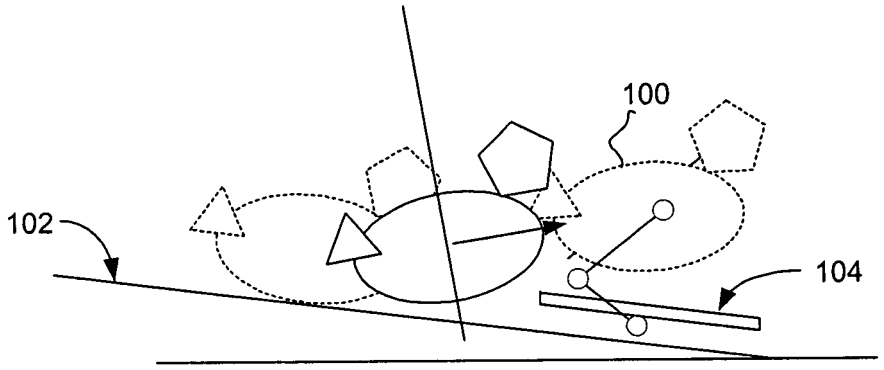
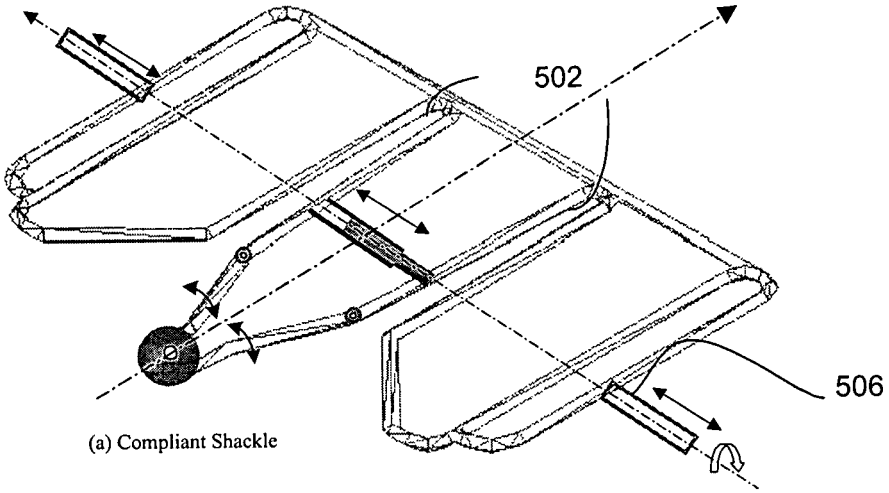


FIG. 5A

Shackle



(a) Compliant Shackle

FIG. 5B

Awaiting Shackle

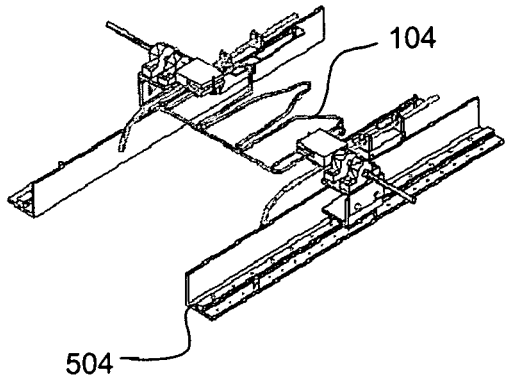


FIG. 5C

Rotated Shackle

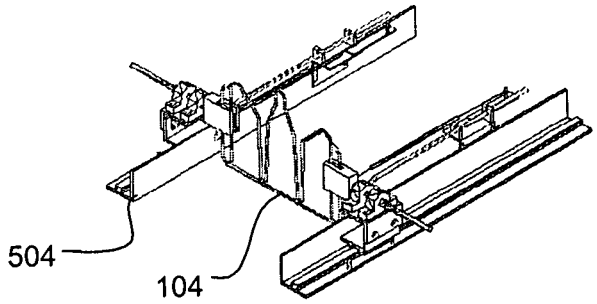


FIG. 6

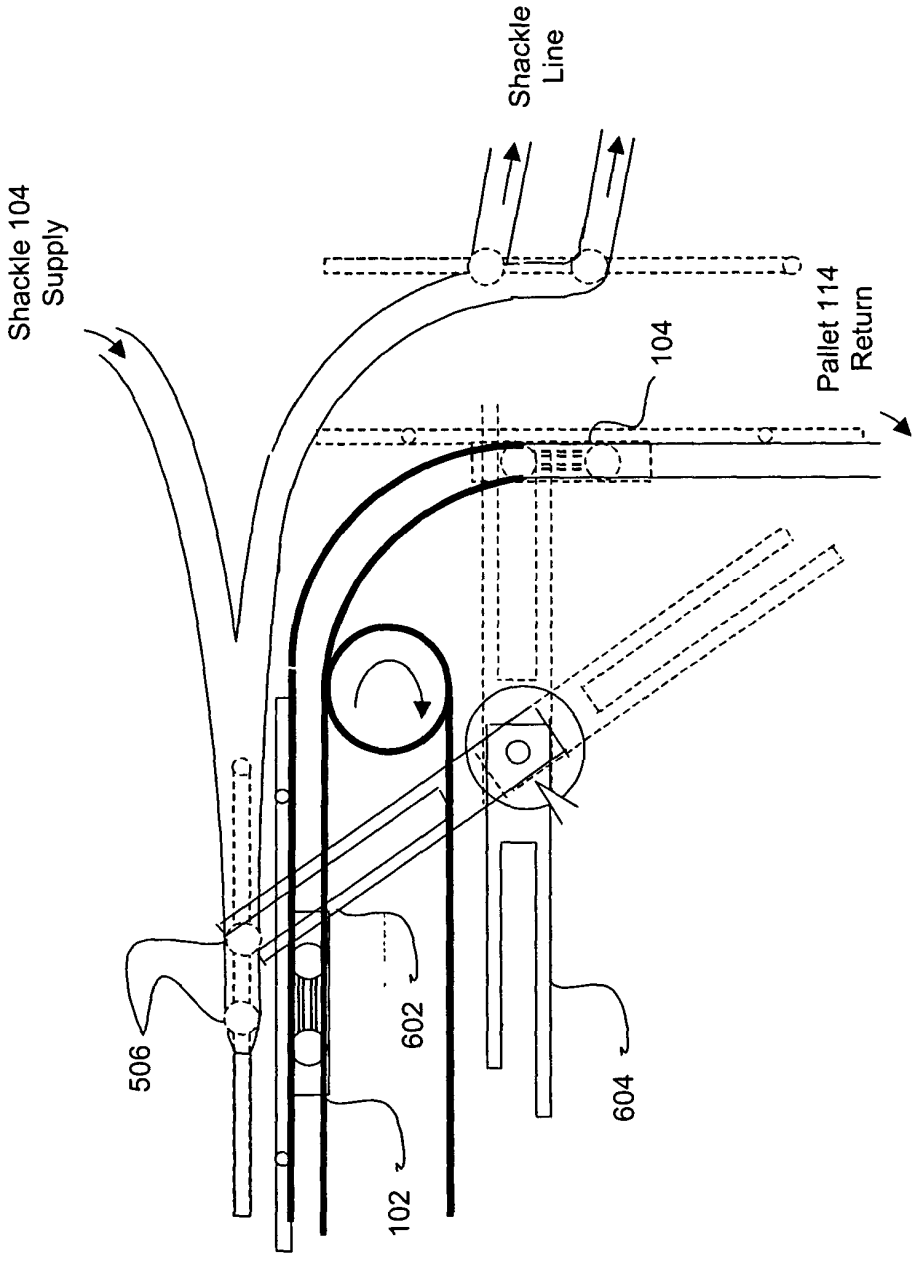

Shackle 104 Supply
Shackle Line
Pallet 114 Return
104
506
602
102
604

FIG. 7A

Imaging System

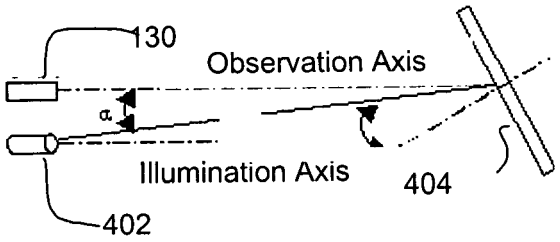


FIG. 7B

Imaging Neural Network

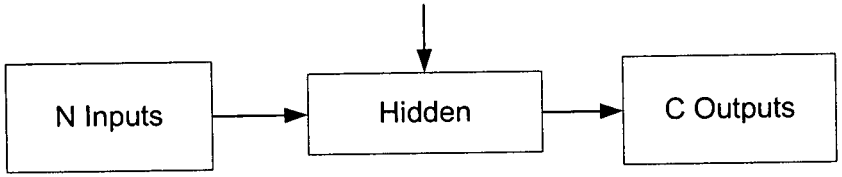


FIG. 7C

Imaging Neural Network

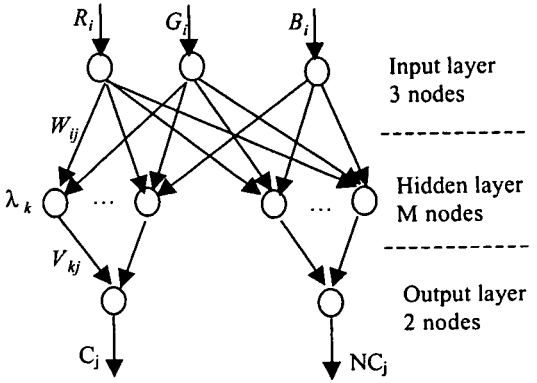
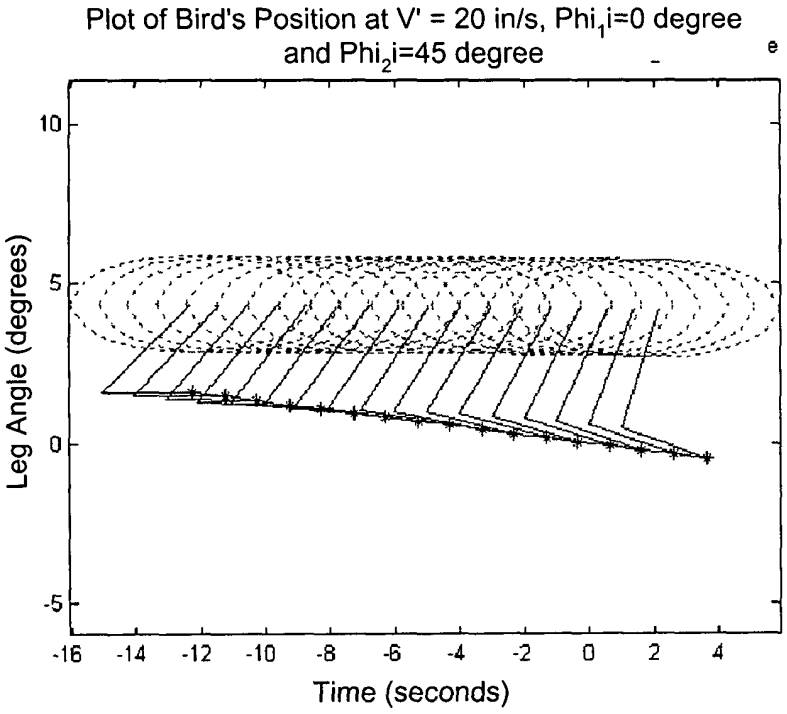


FIG. 8A

Plots for Use with
a Neural Network



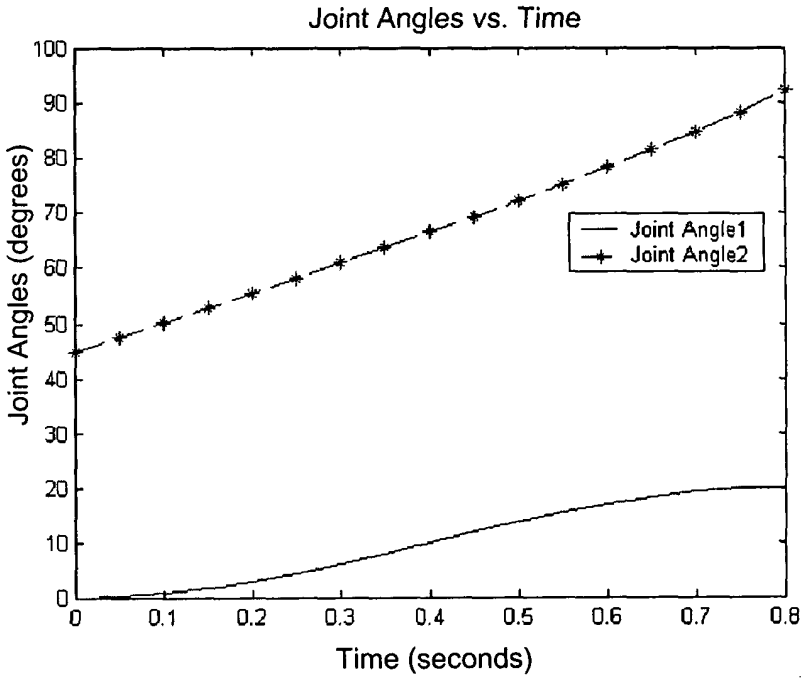
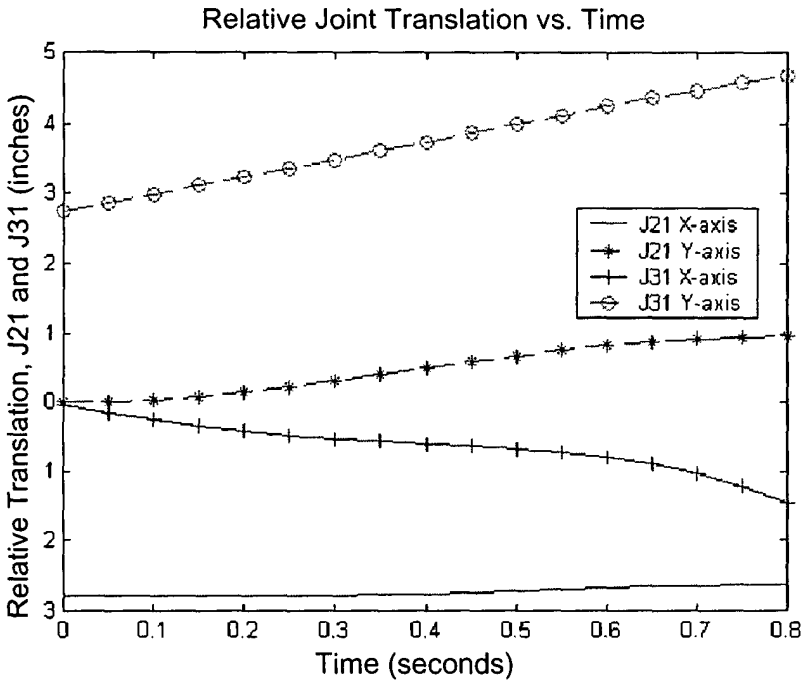


FIG. 8B

Plots for Use with
a Neural Network



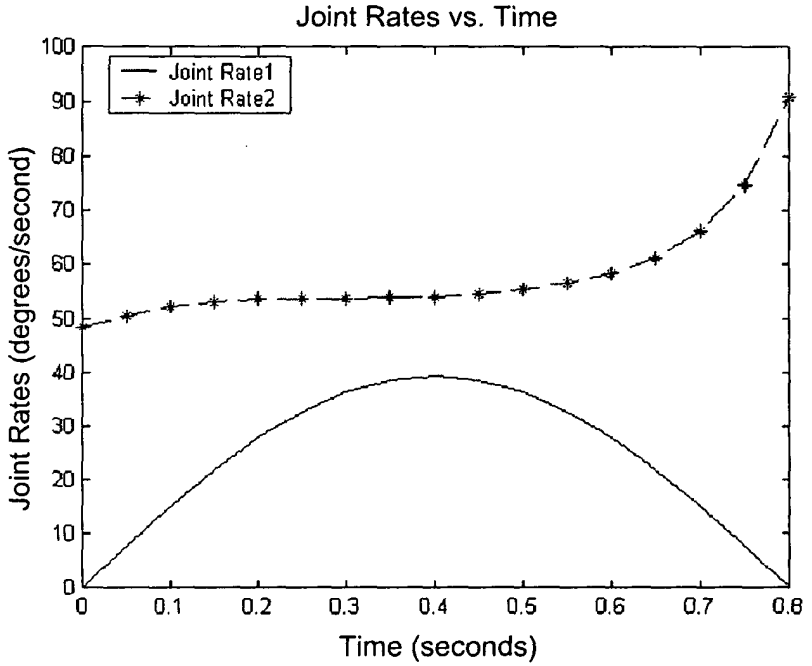


FIG. 8C

Plots for Use with a Neural Network

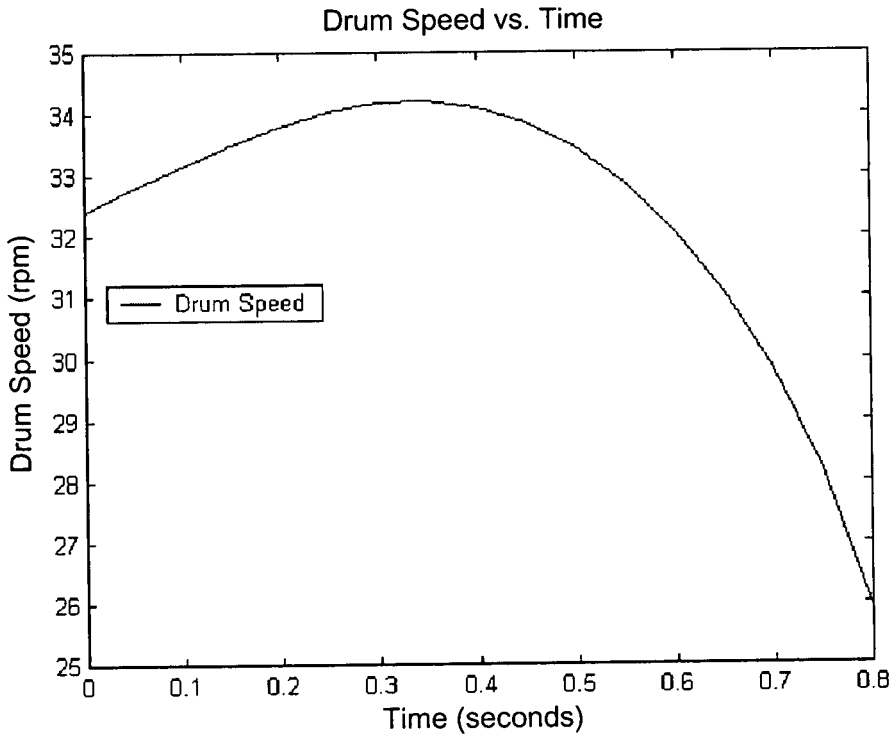


FIG. 9

System Operation Control Sequence

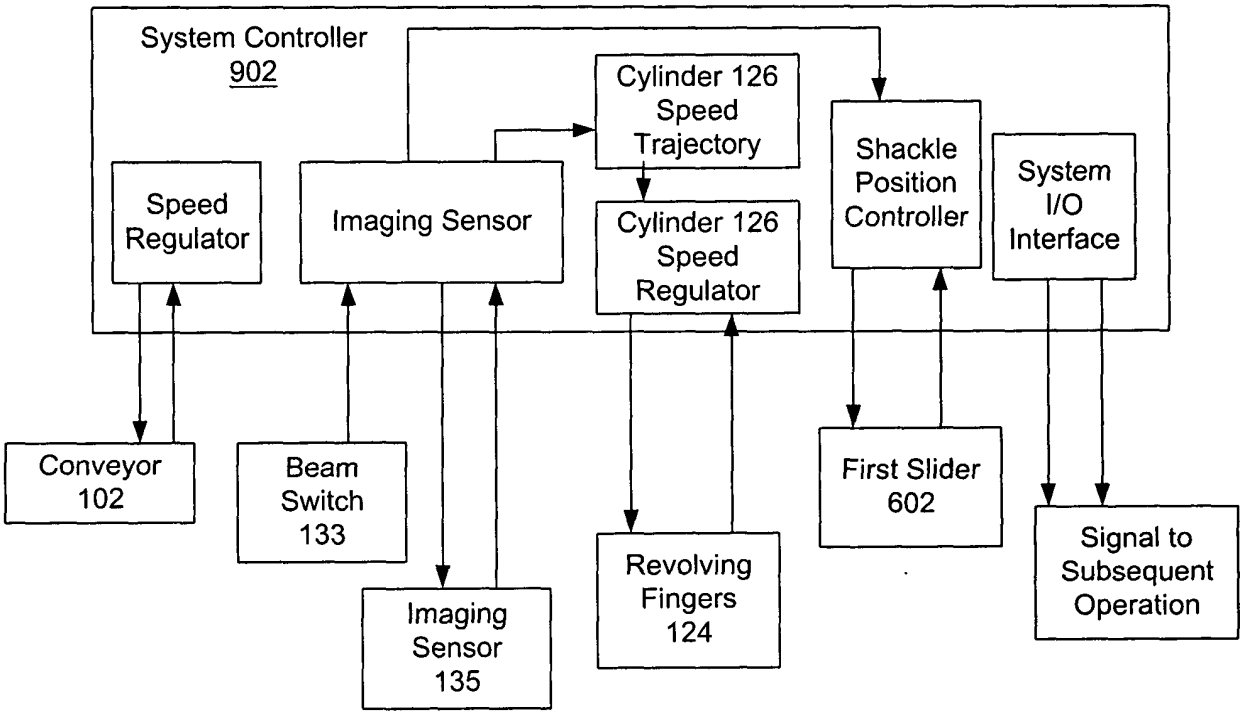


FIG. 10

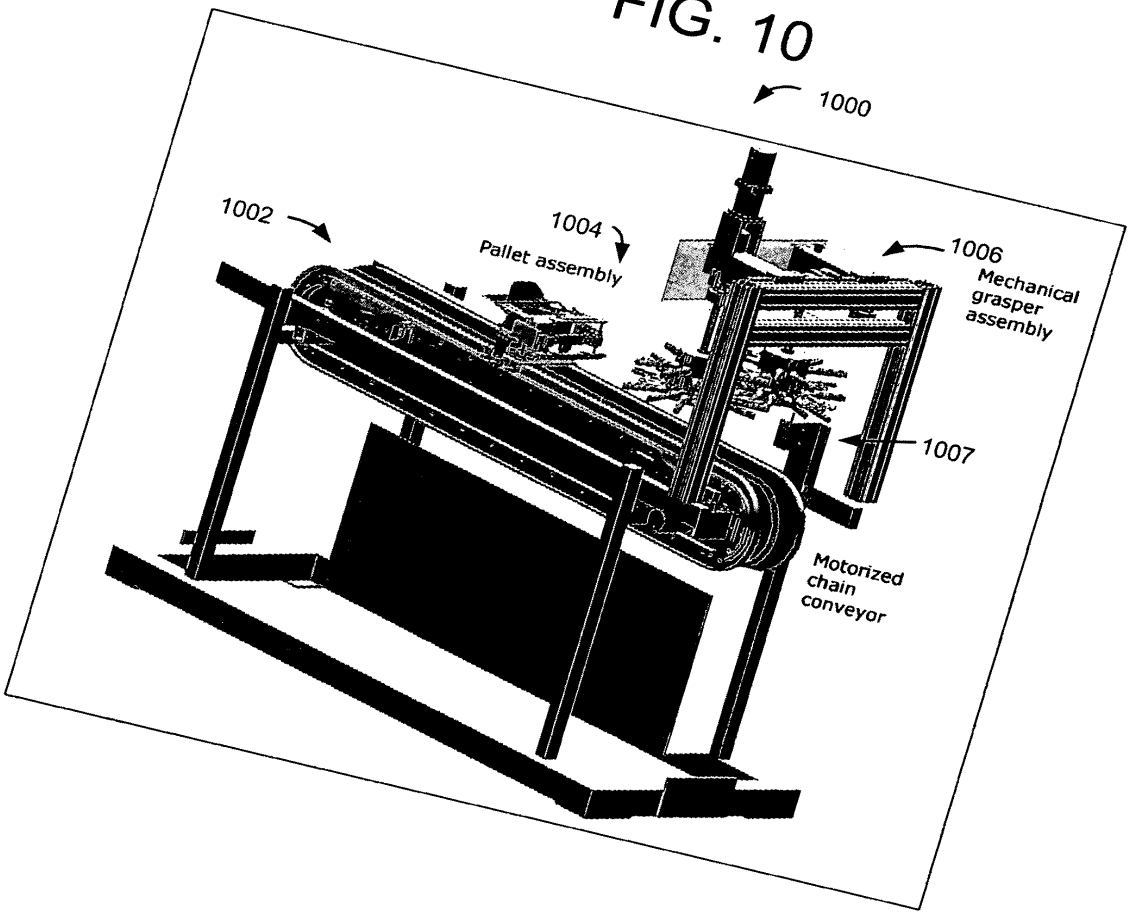
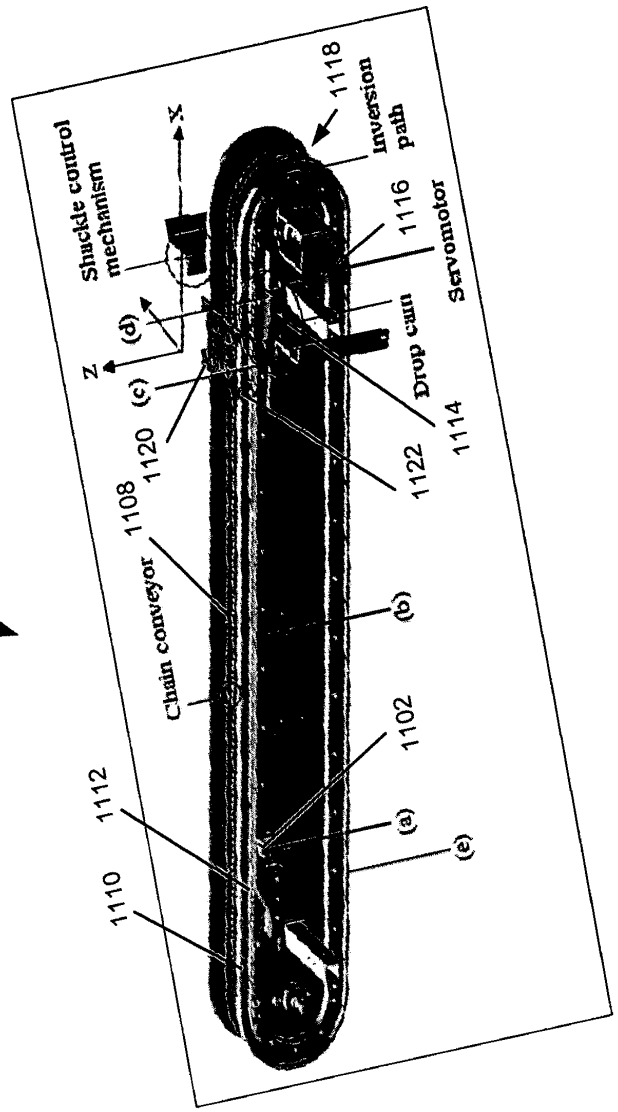

1000
1002
1004
Pallet assembly
1006
Mechanical grasper assembly
1007
Motorized chain conveyor

FIG. 11


1002
Shackle control mechanism
X
Z
(d)
(c)
1120
1108
Chain conveyor
1112
1110
1102
(a)
(e)
(b)
1122
1114
Drop cam
1116
Servomotor
1118
Inversion path

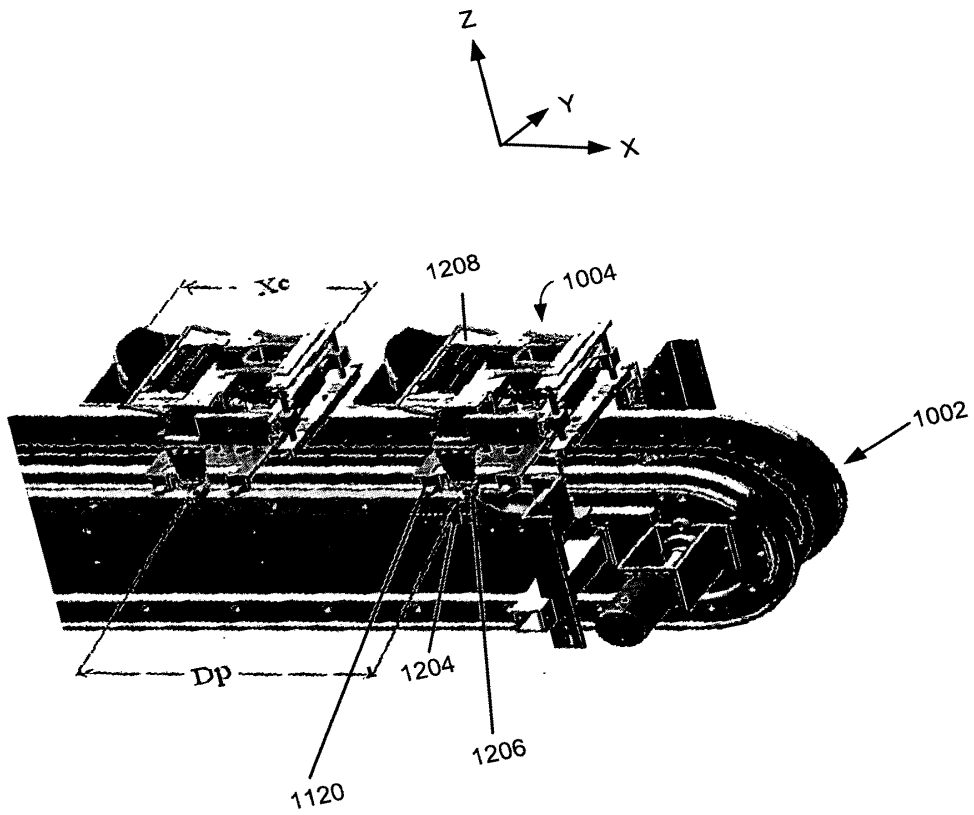


FIG. 12

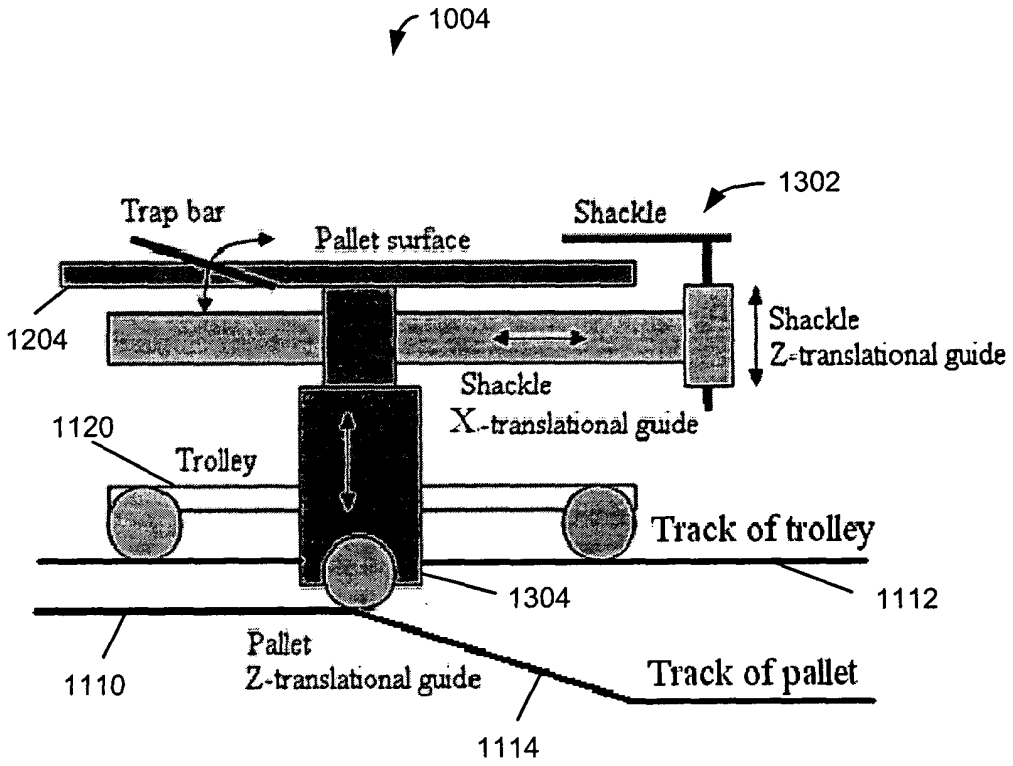

1004
1302
Trap bar
Pallet surface
Shackle
1204
Shackle
Z-translational guide
Shackle
X-translational guide
1120
Trolley
Track of trolley
1304
1112
1110
Pallet
Z-translational guide
Track of pallet
1114

FIG. 13A

FIG. 13B

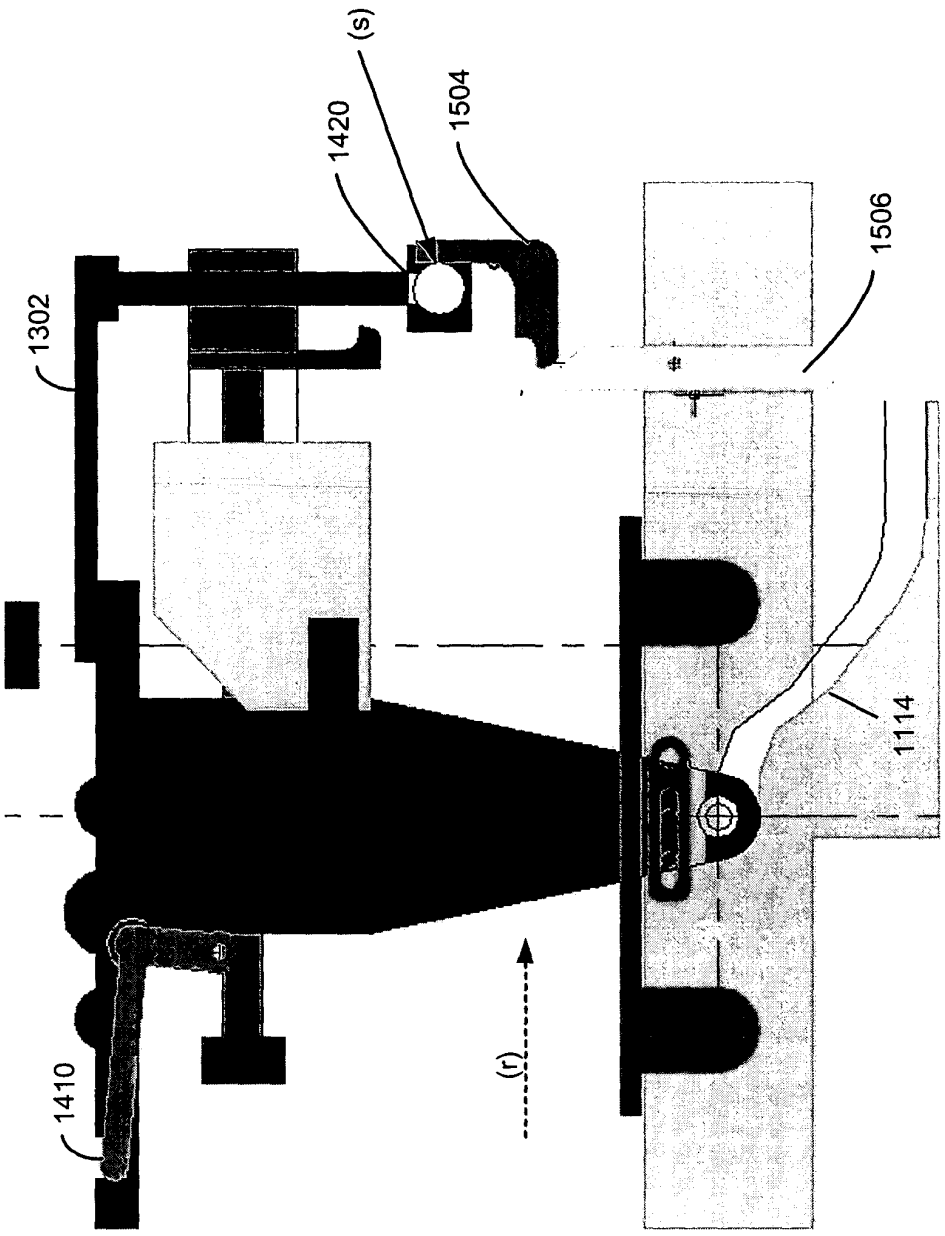


FIG. 13C

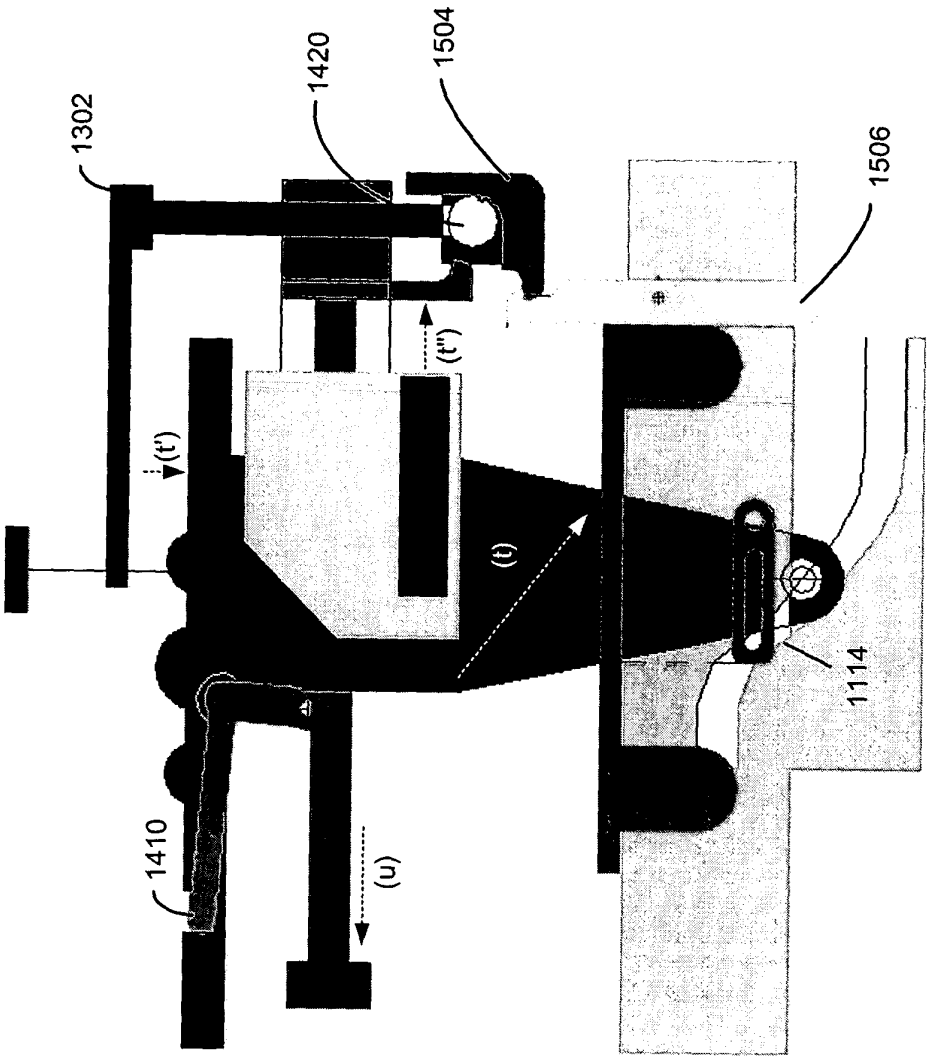


FIG. 13D

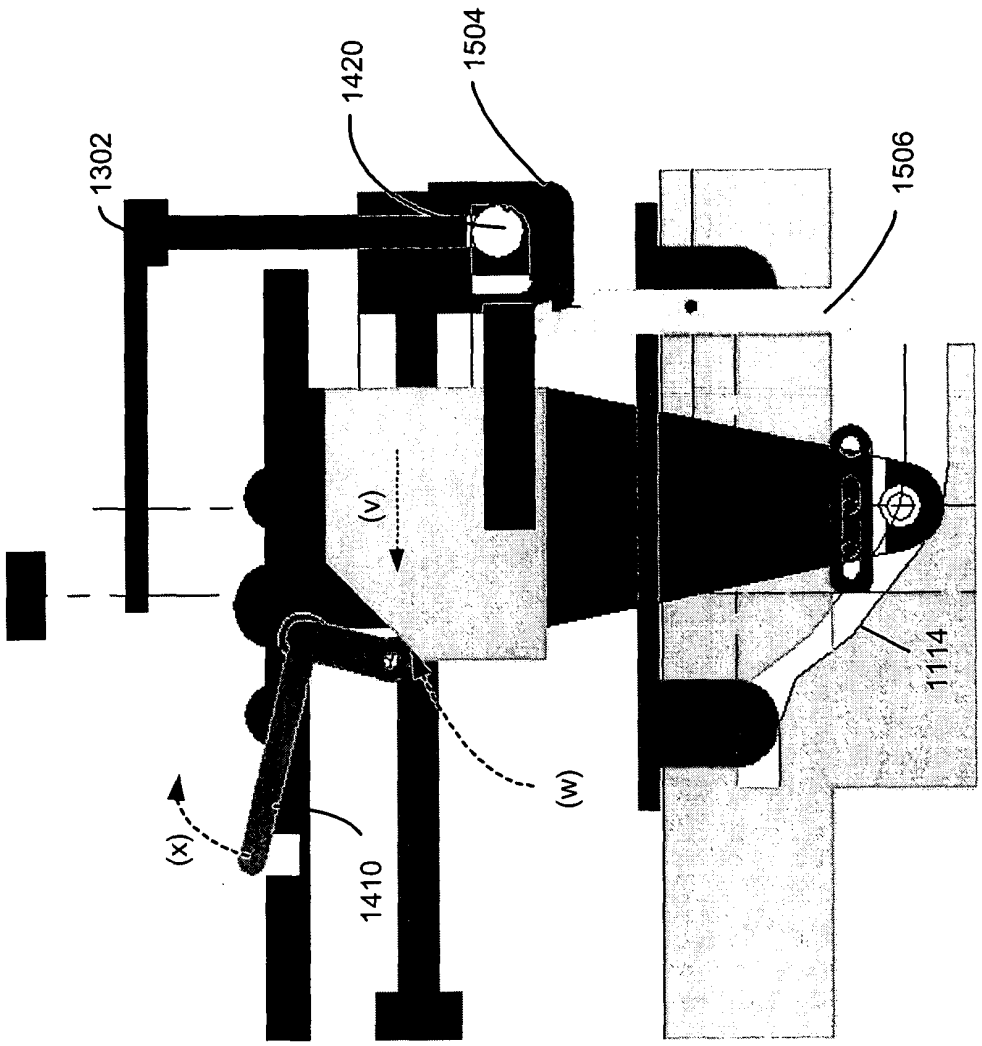


FIG. 13E

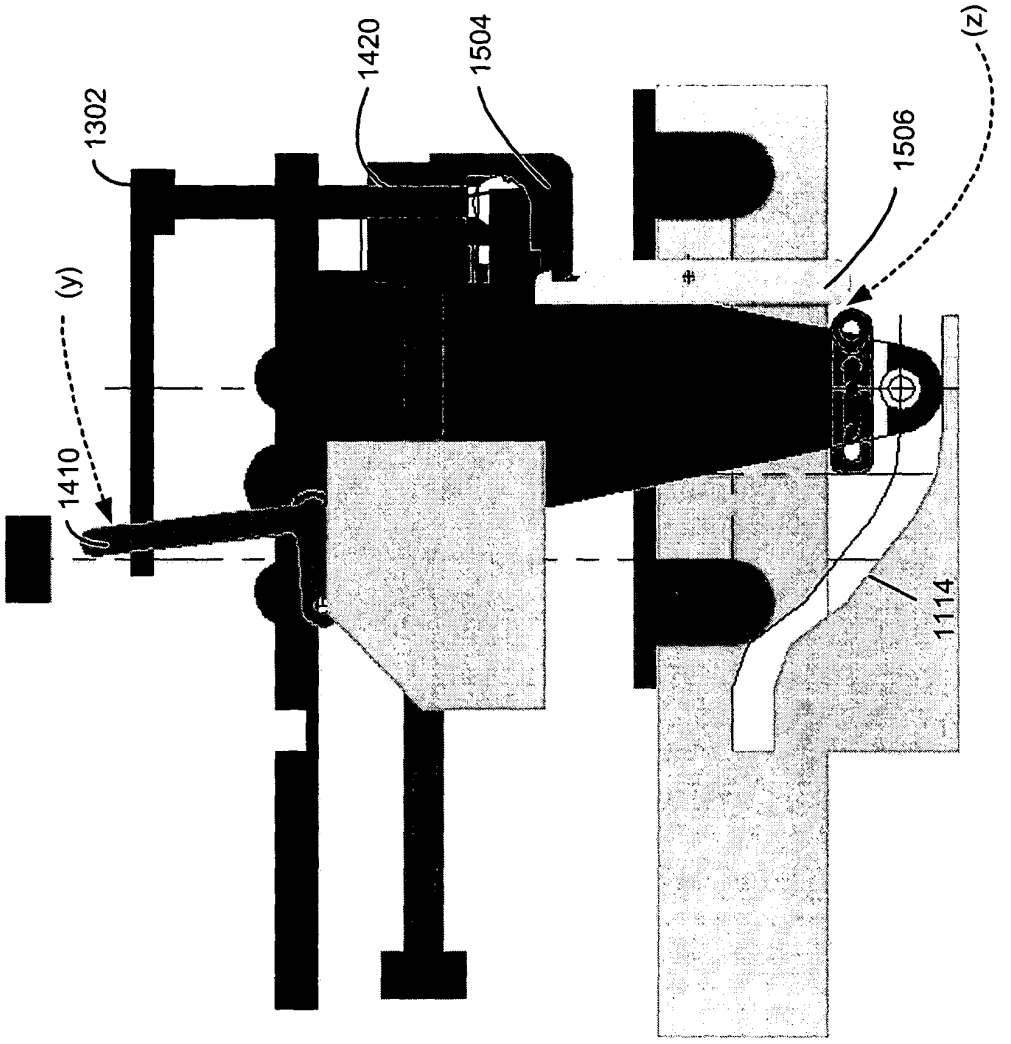


FIG. 14A

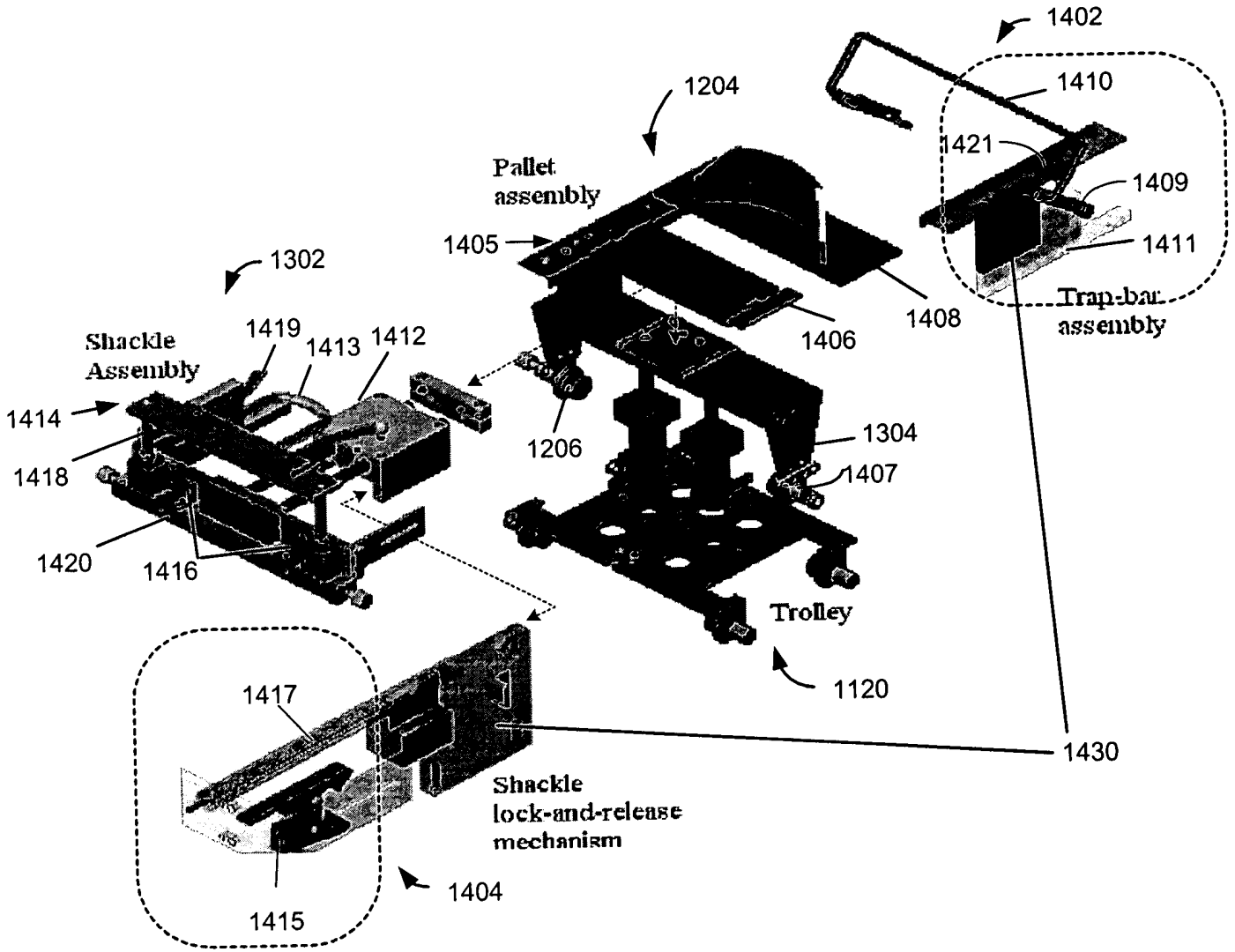

1402
1410
1421
1409
1411
Trap-bar assembly
1204
Pallet assembly
1405
1408
1406
1302
Shackle Assembly
1419
1413
1412
1414
1418
1206
1304
1407
1420
1416
Trolley
1120
1417
1430
Shackle lock-and-release mechanism
1404
1415

FIG. 14B

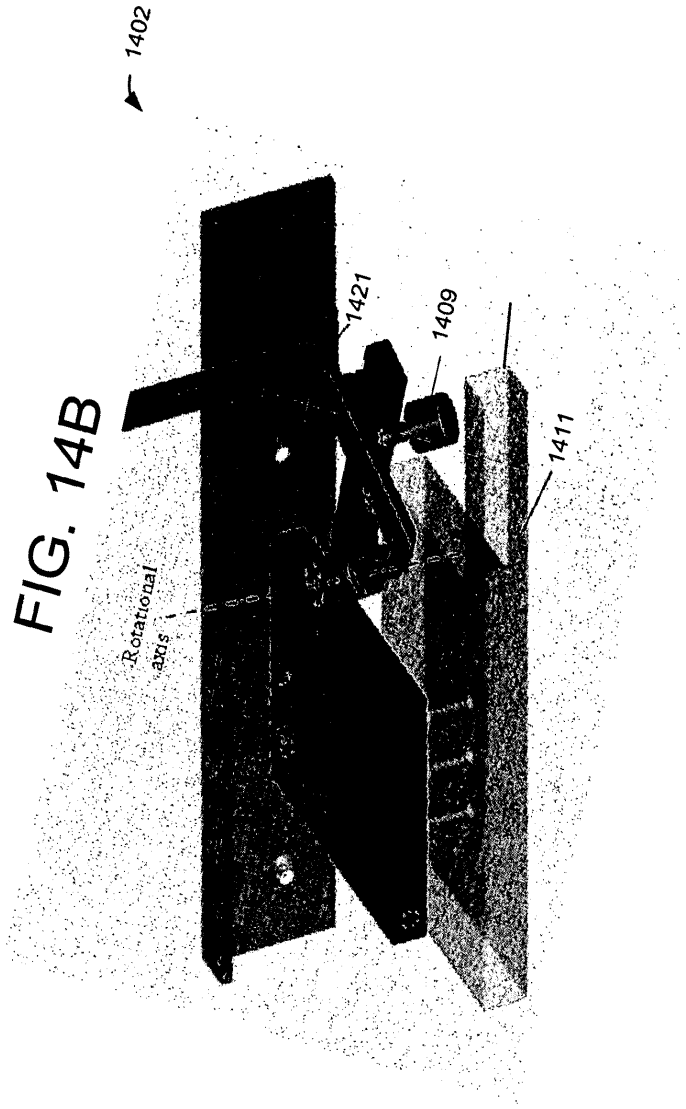


FIG. 14C

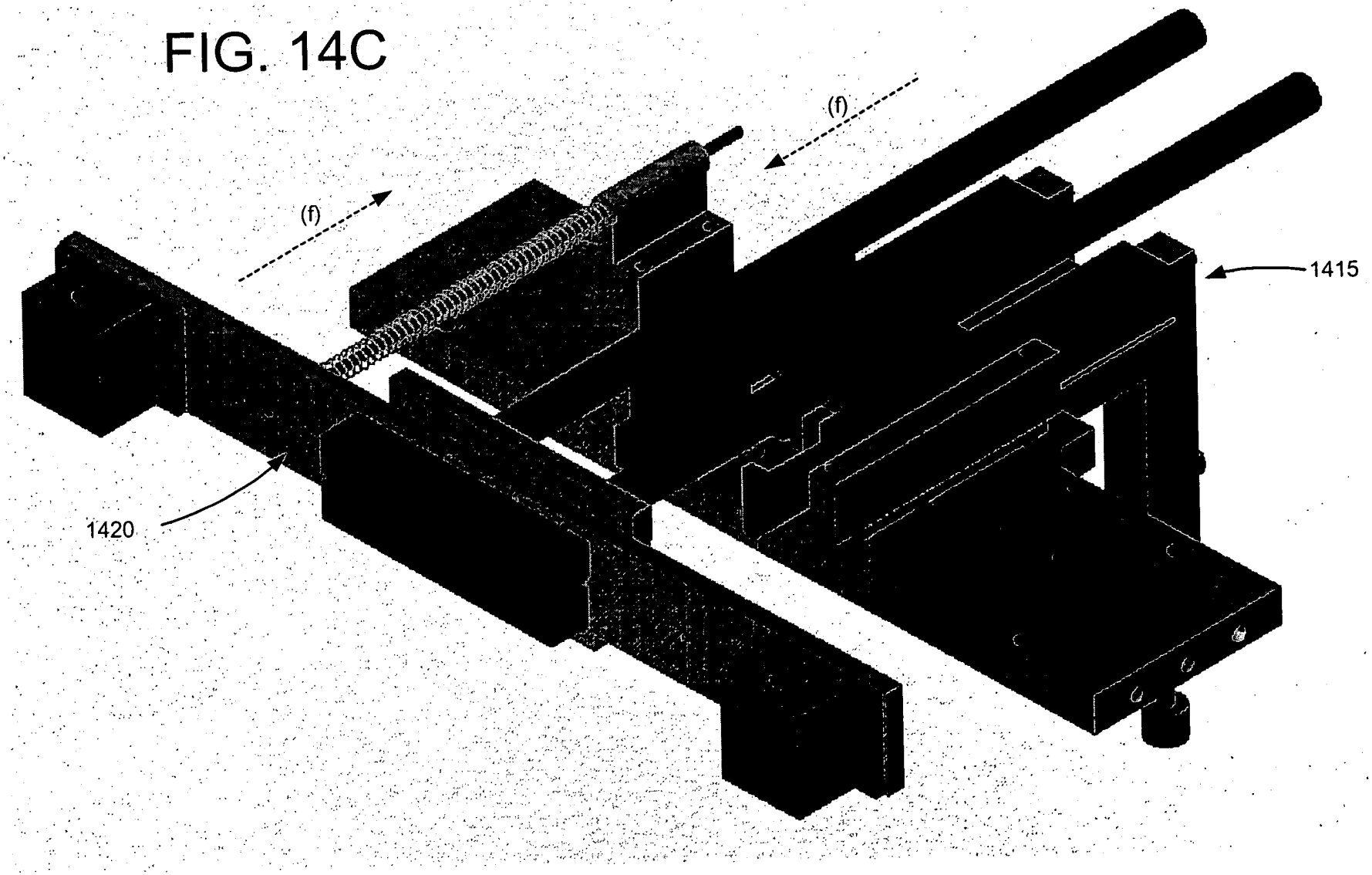
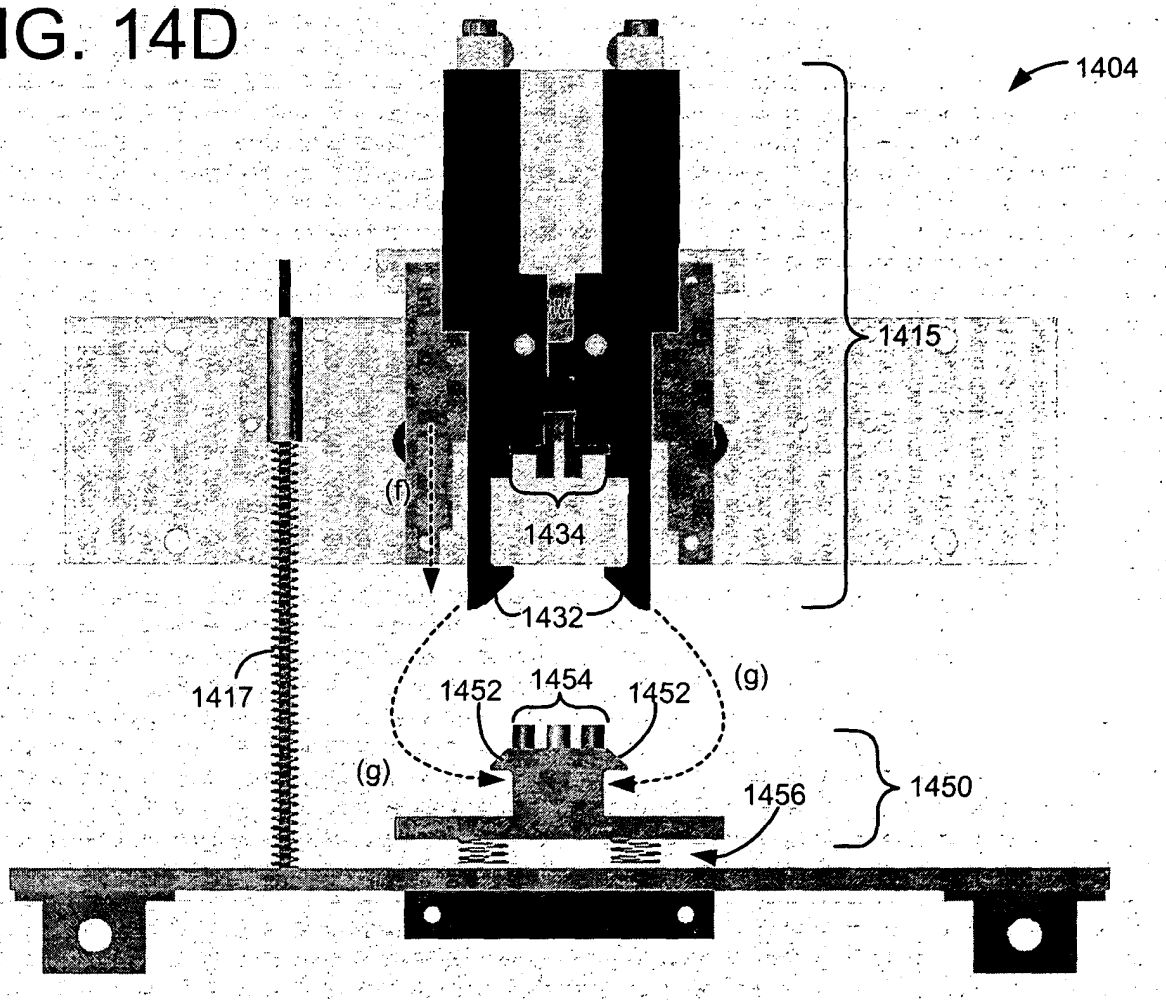


FIG. 14D



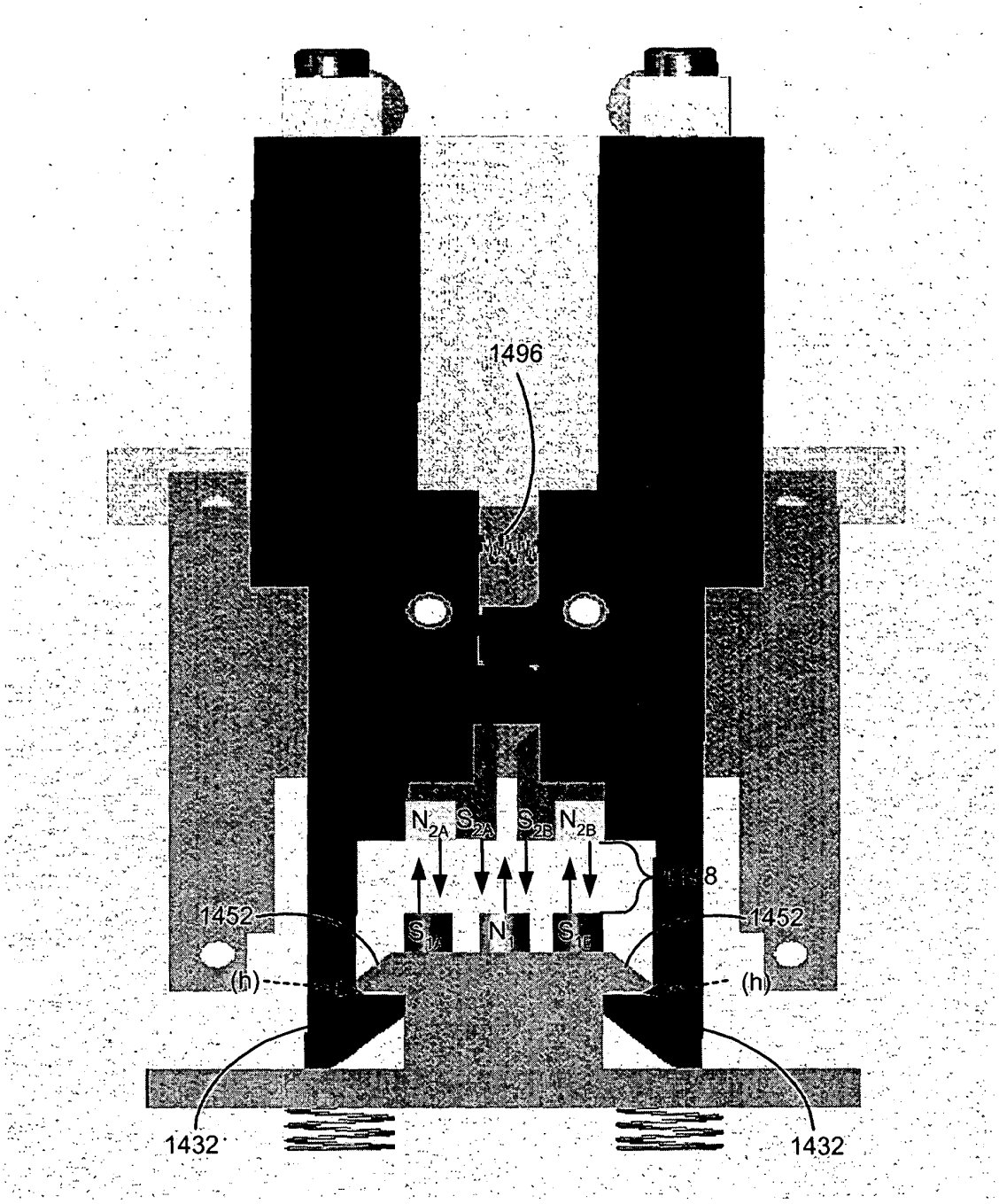


FIG. 14E

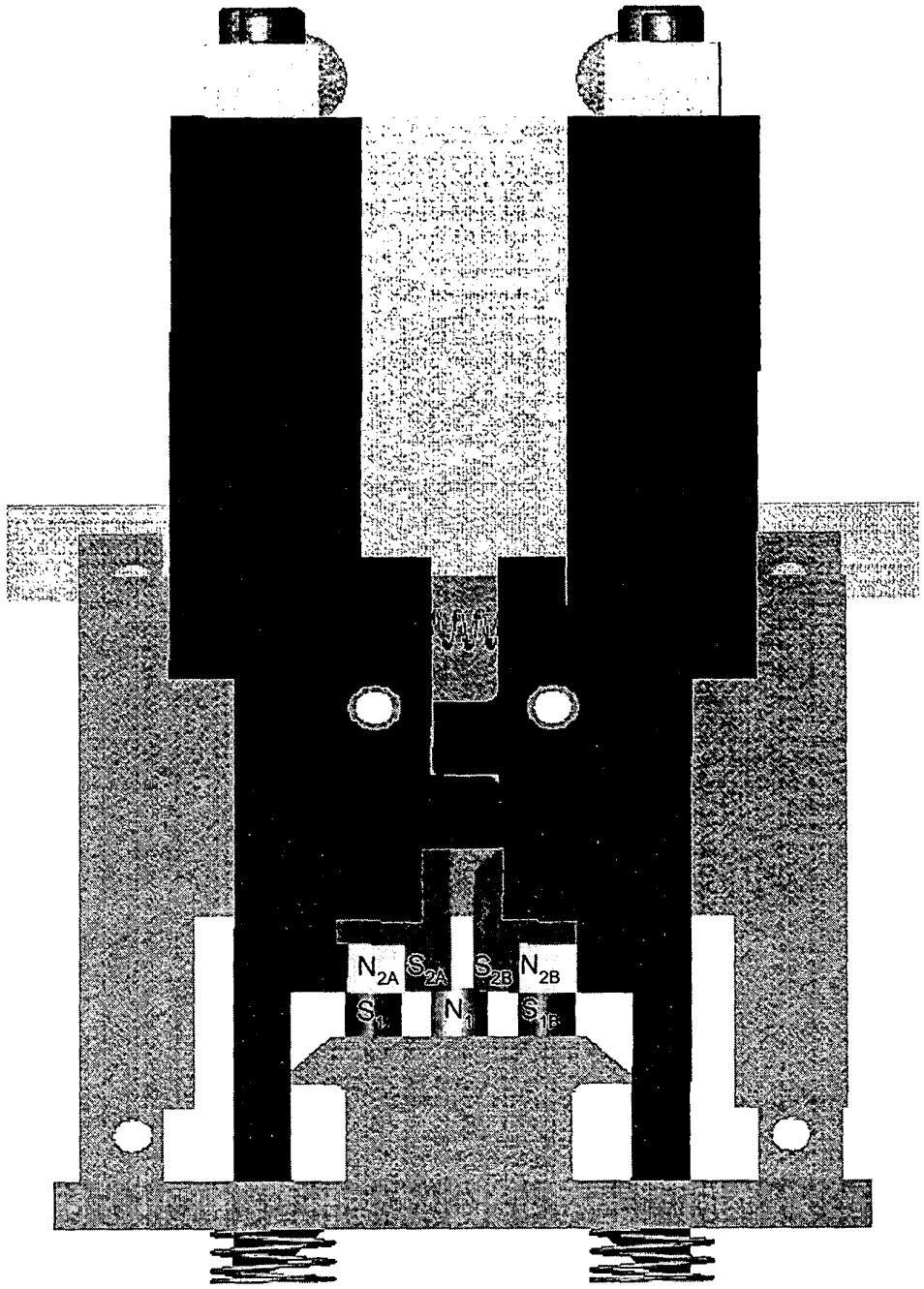


FIG. 14F

FIG. 14G

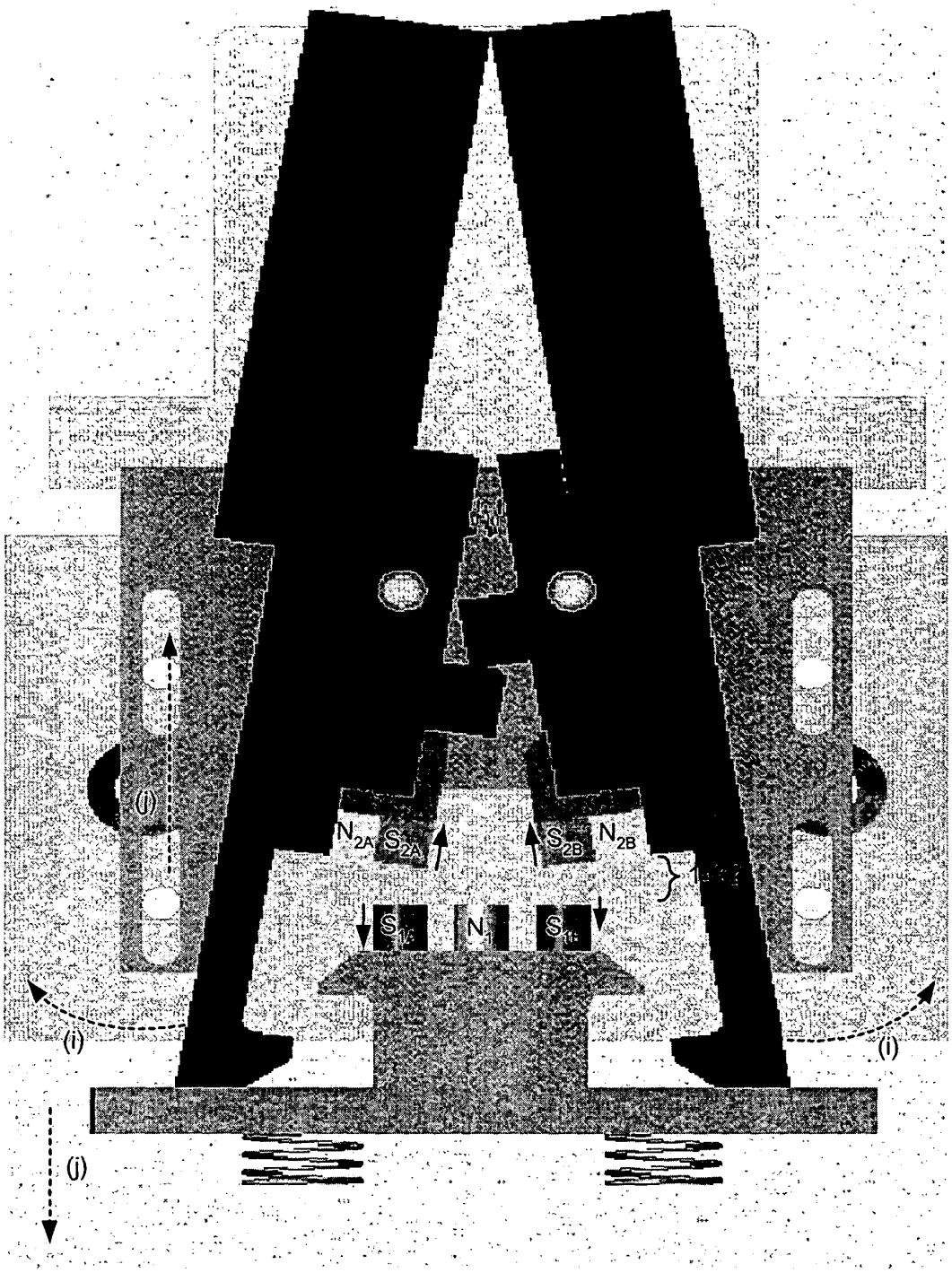
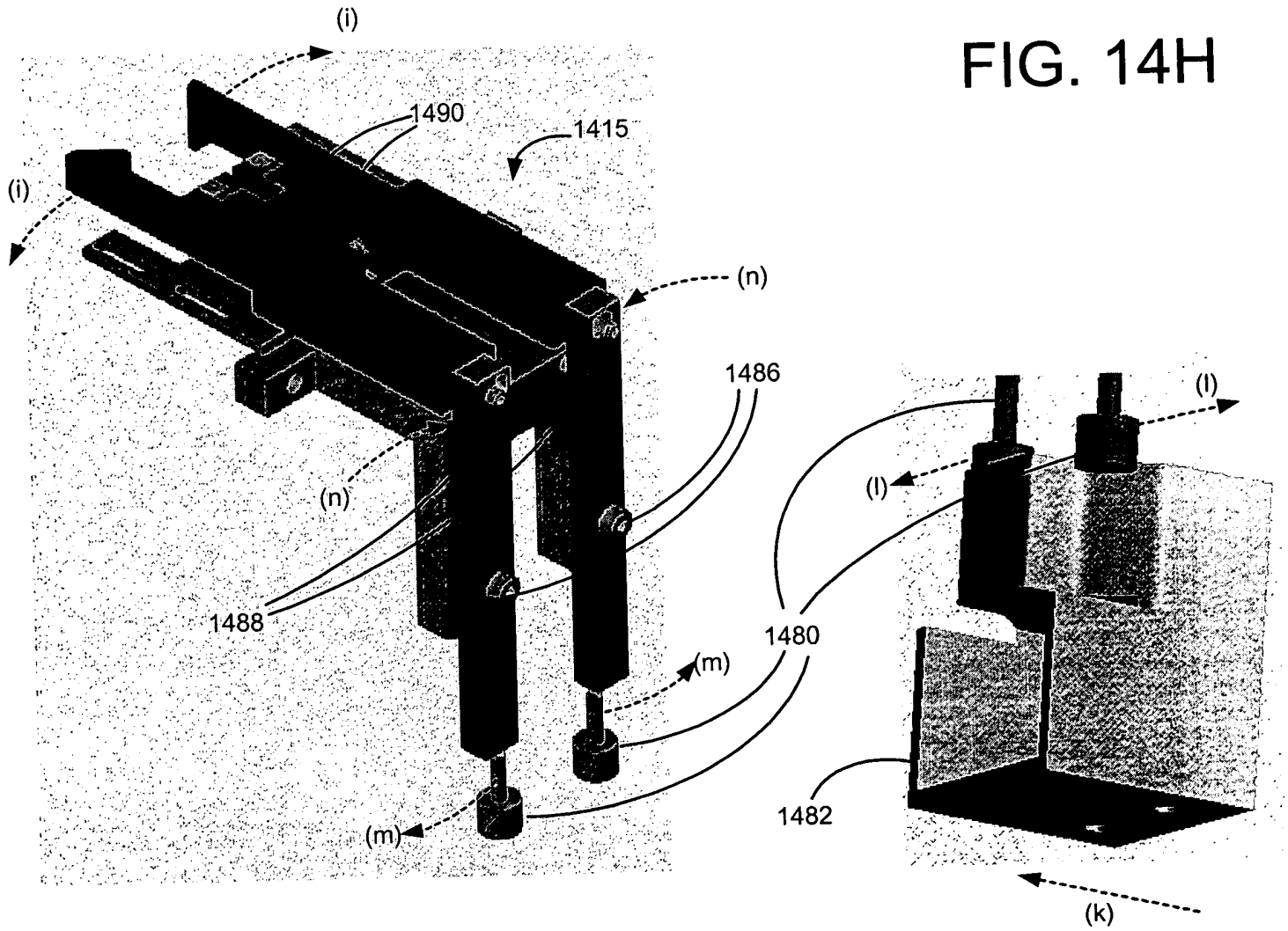


FIG. 14H



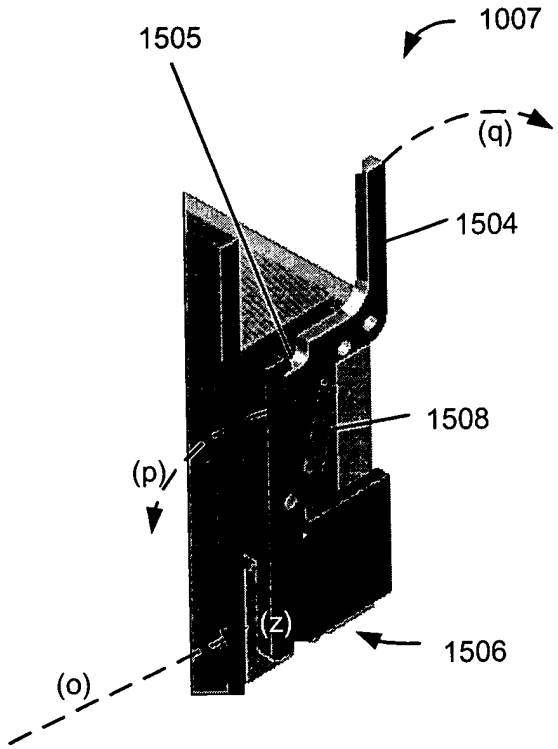


FIG. 15

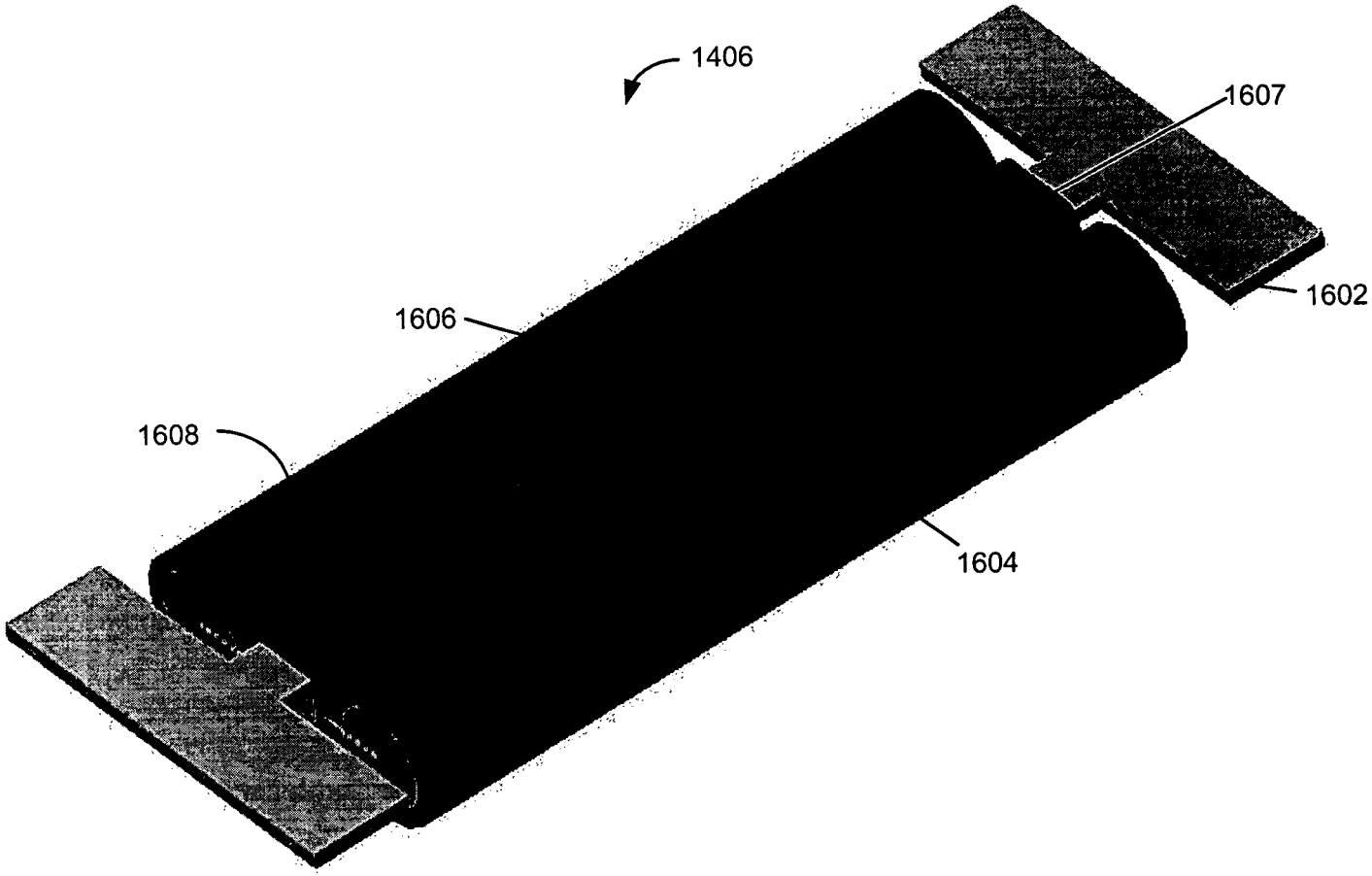


FIG. 16

FIG. 17

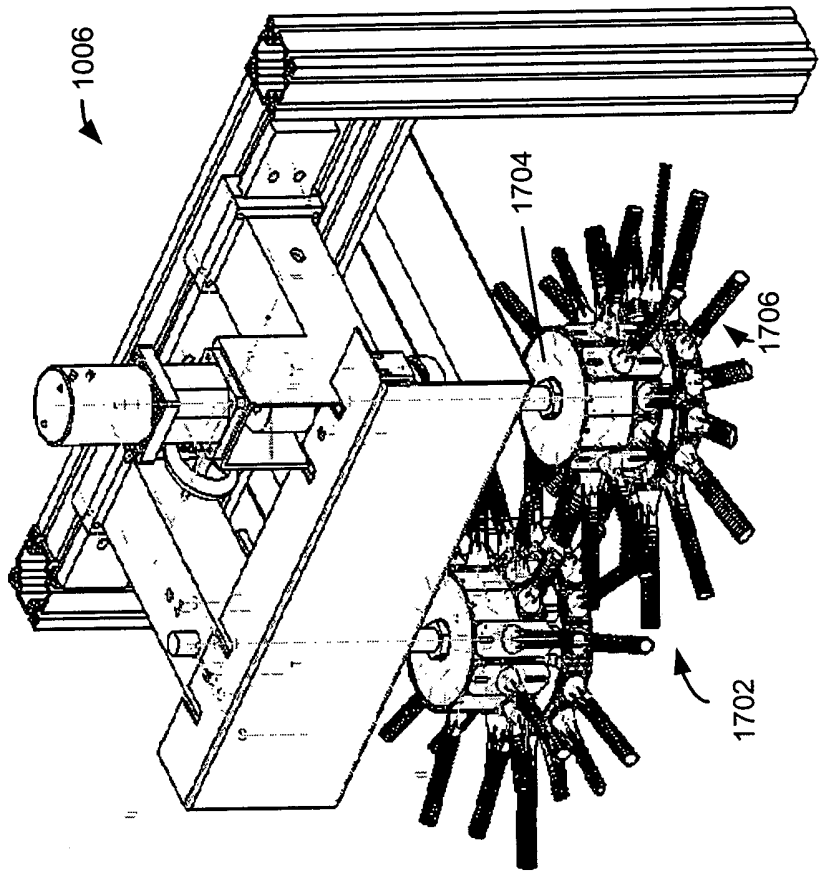


FIG. 18

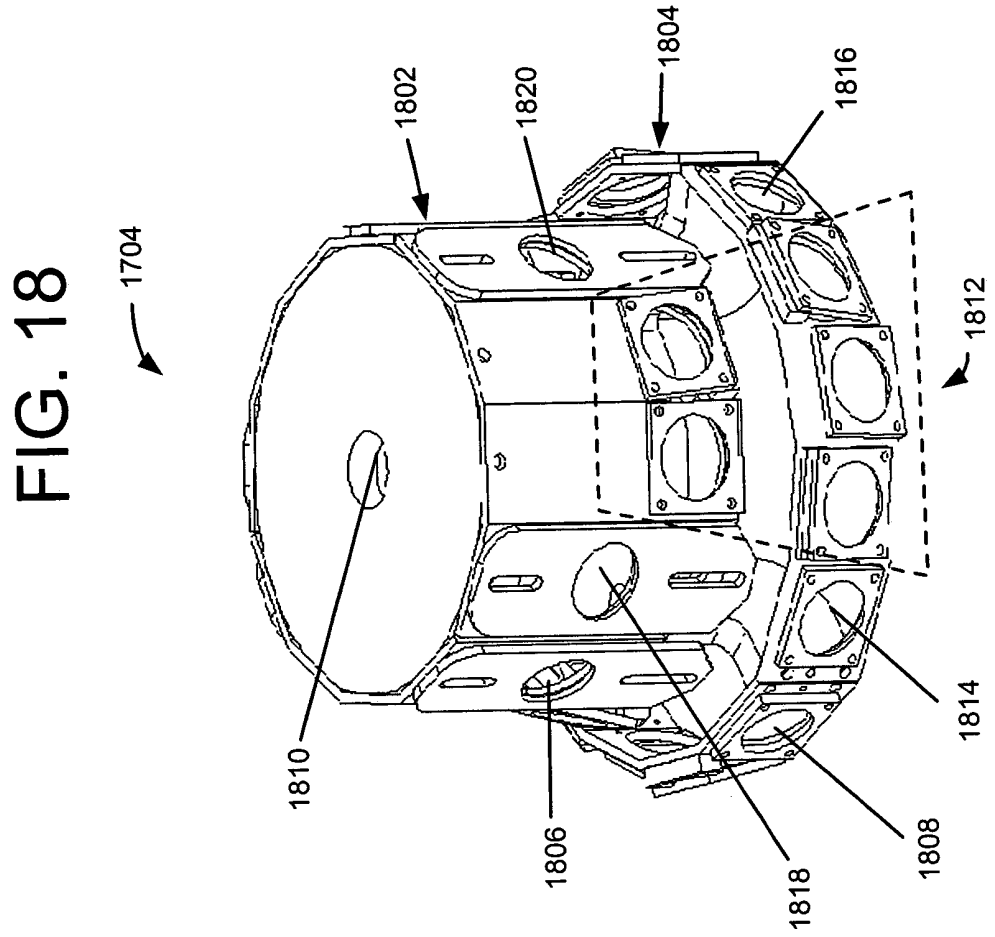
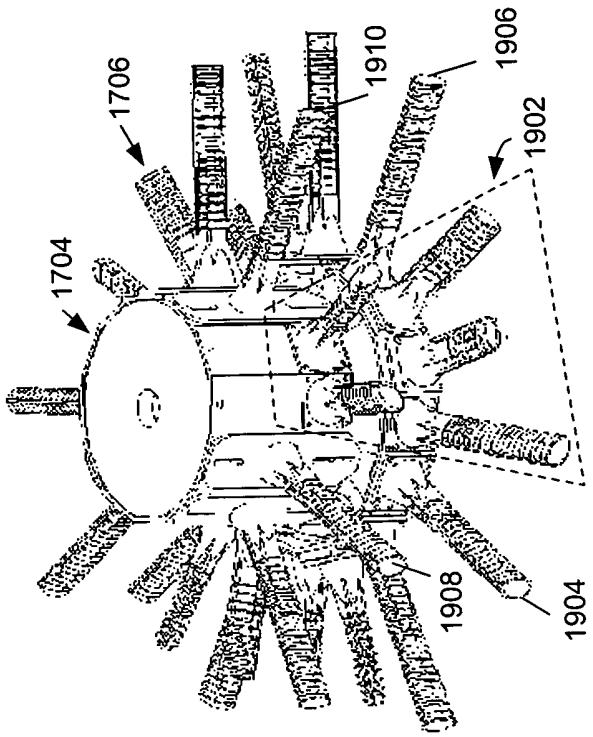


FIG. 19



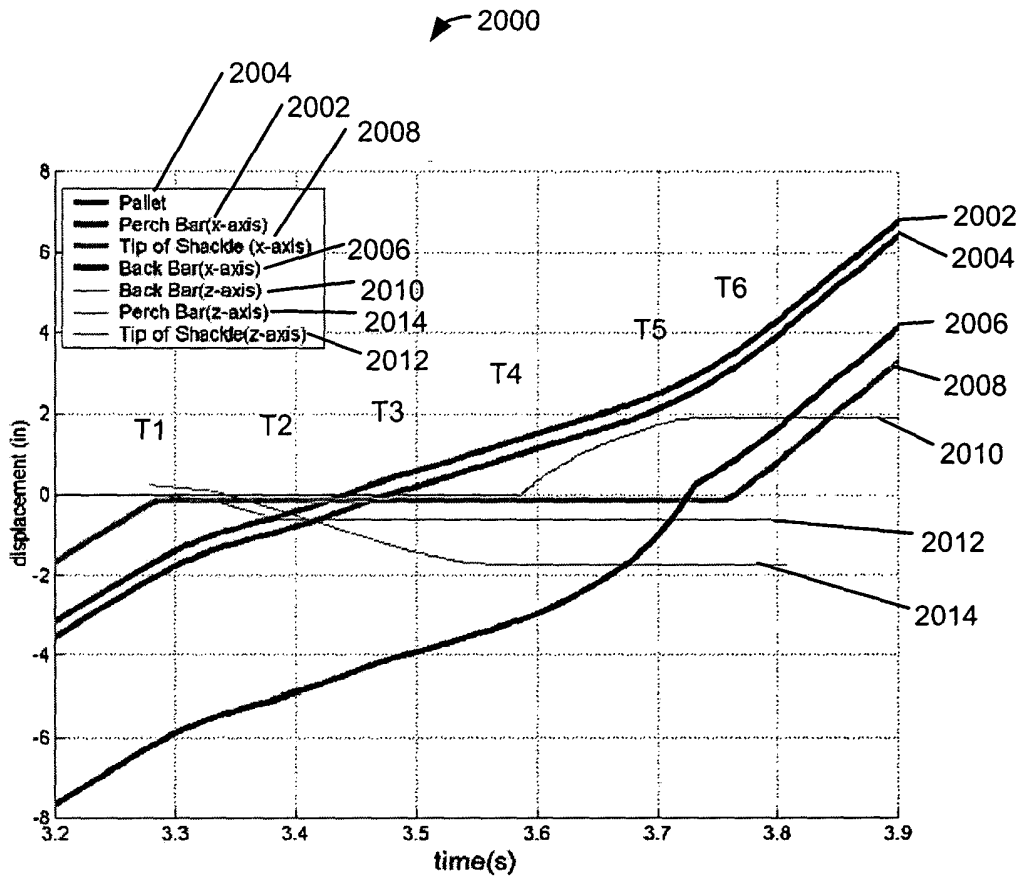
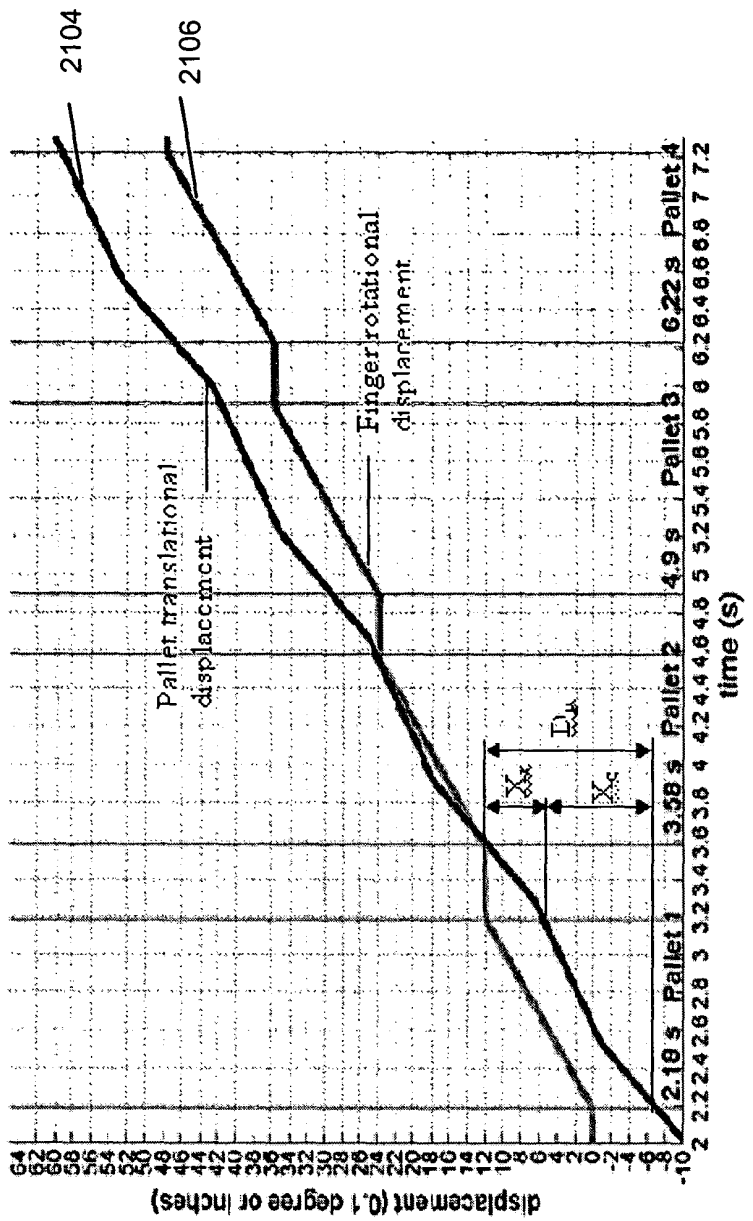

2000
2004
2002
2008
Pallet
Perch Bar(x-axis)
Tip of Shackle (x-axis)
Back Bar(x-axis)
Back Bar(z-axis)
Perch Bar(z-axis)
Tip of Shackle(z-axis)
2006
2010
2014
2012
T1
T2
T3
T4
T5
T6
2002
2004
2006
2008
2010
2012
2014
displacement (in)
time(s)
8
6
4
2
0
-2
-4
-6
-8
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9

FIG. 20

FIG. 21


2102
2104
2106
Pallet translational displacement
Finger rotational displacement
displacement (0.1 degree or inches)
time (s)
2.18 s
Pallet 1
3.58 s
Pallet 2
4.9 s
Pallet 3
6.22 s
Pallet 4